1. **Executive Summary**

The Six Month Study on the Feasibility of the Facility

The goal of this study was to investigate and document the technical feasibility of an intense Neutrino Source Based on a Muon Storage Ring. Colleagues from several national and international laboratories with expertise in the different areas were asked to work closely together with the study group at Fermilab and the members of the *Neutrino Factory and Muon Collider Collaboration.* The charge from the Fermilab directorate to the study group represents questions which are of basic interest for a laboratory that is trying to define a future program: What is the design concept and can it meet the performance goals? What is the R&D that is required to bring us from the state that exists today to the point where a conceptual design can be proposed? What are the most likely cost drivers and where are the potential technical risks? And, finally: What are the Environment, Safety and Health issues that have to be addressed during construction and operation?

The basic question about feasibility is addressed throughout the report and the answer is: yes. The result of this study clearly indicates that a neutrino source based on the concepts presented here is technically feasible [1]. According to our present understanding it will not quite meet the intensity specified and it should probably have an energy lower than initially specified (50 GeV). There is clear indication though that we would and should improve the performance and also how it could be done, but it will need appropriate support for the ongoing R&D. The study summarizes the R&D required that would lead to a conceptual design. The identified topics worth mentioning here are certainly, the proton driver and the target area, the performance and the construction of an induction linac, the uncertainties in the simulation of emittance cooling together with the performance of the associated hardware for the cooling channel, and finally the development of the superconducting rf cavities required for acceleration. All these subjects will have to be addressed in parallel in order to arrive, on a reasonably rapid time scale, at a point where a laboratory could initiate a conceptual design report. These subjects are equally critical for the performance of the facility and focusing on only one of them at a time, perhaps due to resource limitations, will severely impact the time scale. As requested in the charge, the cost drivers have been identified. Finally, many of the ES&H issues associated with the facility are very similar to those that have been encountered and solved during the construction and operation of other facilities at Fermilab and elsewhere while others are quite novel. It is concluded here that with adequate planning in the design stages, these problems can be adequately addressed.

The Basic Advantages of a Neutrino Factory

A neutrino factory as a facility has a number of advantages that are worth pointing out. The most essential one is that it is a unique facility, whose physics justification is becoming increasingly clear. In addition, an intense cold muon source will open up new windows of research in a manner similar to what has happened with lasers, synchrotron light sources, FEL's, and neutron sources. An intense neutrino beam will most probably be the first application and is considered in this report. Staged upgrades of the cooling channel can lead to increased intensity neutrino beams, and perhaps ultimately as the technology improves, to muon colliders. In a similar way the final energy of the facility can be upgraded in steps. Both parameters can be adjusted to meet the funding realities that will have to be imposed at some point to make the first step affordable.

Another unique characteristic arises from the fact that the cost of the total facility can be balanced between the detector and the accelerator. Over a wide range the measure of the quality of physics is proportional to the product of $\mathbf{E}.\mathbf{I}.\mathbf{M}$ = constant, where **E** is the energy of the muon beam, **I** is the intensity of the muon beam and **M** is the fiducial mass of the detector. Minimizing the cost for the product requires equal investment into accelerator (acceleration = **E)**, the cold muon source (proton driver through emittance cooling channel = **I)** and the detector (=**M**). Balancing $\mathbf{E}.\mathbf{I}$ with **M** will minimize the total cost and will require the development of accelerator as well as detector technology. A more general advantage is that the small footprint of the facility which will allow it to fit under an existing laboratory site. The same is true for the detectors, one of which could be in a different US Laboratory or, for a very long baseline experiment in Europe or Japan, other laboratory sites could be used. The international nature of the *Neutrino Factory and Muon Collider Collaboration* leads naturally to this collaborative approach. DOE (Department of Energy) and NSF (National Science Foundation) are endorsing this approach given the large number of universities already involved. Responsibilities and cost can be shared between different groups, laboratories or even countries.

The Interest of the Laboratory

All the arguments stated above on the basic advantages are useful only if the proposed program fits the mission of the laboratory, its specific situation and its ongoing program. The question of mission is addressed by the contemporaneous study [2] that investigated the physics program which would accompany this facility. With the strong ongoing program at Fermilab today and over the next couple of years, a balance between supporting the present operation and developing a plan for the future has to be found. The limited resources available to Fermilab make it imperative to use the resources that have been collected under the umbrella of the *Neutrino Factory and Muon Collider Collaboration* and the other organizations supporting this program. Funding has come from DOE, NSF, the State of Illinois, the different universities within the state of Illinois and the additional national and international laboratories which have all made their expertise available. Many of these groups have assumed responsibilities within the R&D program already and their contributions can be found throughout the report. For the ongoing program, it is obvious that an intense proton source would further empower the laboratory to better exploit its investments in Run II, NuMI/MINOS, Mini BooNE, fixed target etc. The existence of an intense muon source would define an interesting and new program, with many opportunities in addition to those offered by a neutrino source.

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Fermilab, March 31st 2000

REFERENCES

[1] Neutrino factory technical study coordinator: N. Holtkamp and D. Finley. See http://www.fnal.gov/projects/muon_collider/nu-factory/nu-factory.html
[2] Neutrino factory physics study coordinators: S. Geer and H. Schellman. See http://www.fnal.gov/projects/muon_collider/nu/study/study.html

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